a reverse action being observed under certain circumstances with india-rubber, suggested to the author experiments to ascertain whether vulcanized india-rubber stretched by a weight is shortened by increase of temperature. Accordingly, on trial, it was found that this material, when stretched by a weight capable of doubling its length, has that length diminished by one-tenth when its temperature is raised 50° Centigrade. This shortening effect was found to increase rapidly with the stretching weight employed; and, exactly according with the heating effects observed with different stretching weights, entirely to confirm the theory of Professor Thomson.

February 5, 1857.

The LORD WROTTESLEY, President, in the Chair.

THE BAKERIAN LECTURE was delivered by MICHAEL FARADAY, Esq., F.R.S., "On the Relations of Gold and other Metals to Light."

The Lecturer gave an exposition, illustrated by experiments, of the substance of a paper presented by him to the Society under the above title. The following is an abstract:—

The author of this paper hopes that the undulatory theory of light, when more fully and perfectly developed, may aid in comparing local actions with those which take place at a distance, and even help towards the comprehension of the physical means by which the latter are carried on; and with that view he endeavoured, experimentally, to subject a ray of light to the action of particles, so small in size as to have an immediate and near relation, not only to the undulations of light, but even to the far smaller motions of the parts of the ether, which are supposed to produce, by their joint and successive action, the light-wave. His hope was, that by choosing particles of a fitting substance, experimental results might be obtained which, in the hands of the mathematical philosopher, might aid in perfecting the theory; and for this purpose gold was selected, because of its high optical

qualities, shown in its comparative opacity, whilst possessing a real transparency; its high yellow reflexion and its true green transmission; its known action on light in very minute quantity; its capability of extreme division; its great gravitating force, which could be called upon for aid when the metal was in a state of extreme division; its elementary character; the integrity of its metallic state; the facilities of testing its presence and condition; and, finally, because known phenomena seemed already to indicate differences of action on light consequent upon its division.

The first state of division or attenuation considered, was that conferred on gold by beating into *leaves*. These, with their dimensions and general characters, are well known. Being taken up on glass damped by breathing or moistening, and then water introduced between the glass and the gold as a cushion, the gold can be perfectly stretched, so that when dry it is fit for optical examination; or if a diluted solution of cyanide of potassium be in like manner introduced beneath the gold, it can be more or less attenuated by solution, and then washed and dried. If gold-leaf thus extended and attached, either to glass, or plates of rock-crystal, or mica, be heated, it gradually loses its reflective power and its green colour, and becomes translucent. This change takes place far below the fusing-point of gold, and at a temperature as low as the boiling-point of oil if continued for several hours. When the heat is considerable, the gold-leaf suffers retraction of its parts, and becomes perforated by many fine holes, often symmetric in their form and dimension; but when the heat applied is the lowest competent to produce the change, it does not seem certain that the effect is due to such retraction; a good microscopic examination of this point is required. When pressure is applied to such decoloured gold by a convex piece of rock-crystal of short radius (as half an inch or less), the green colour of the transmitted ray reappears. This production of the green colour by pressure can often be referred to in different states of gold, as a proof, amongst others, that the metal is in the metallic condition. Silver-leaf undergoes a like change by heat, at even a lower temperature.

Division by the Leyden Deflagration.—When a gold wire is deflagrated near the surface of glass plates by a strong electric discharge, it is dissipated in minute particles, which are deposited on the glass. These are seen by the microscope to be of different sizes;

but by far the greater part are so minute as not to be distinguishable separately. The general film is of different colours by transmitted light, being grey, violet, or green; and often on the central or nearest part of the discharge, where the heat has been active, is of a fine ruby colour. All these particles act with acid and chemical reagents as gold acts; and there is no reason to believe they are anything other than metallic gold. They appear with precisely the same colours and characters, whether the deflagrations are made in common air, in oxygen, or in hydrogen; and whether the deposits are formed on glass, rock-crystal, topaz, or mica. When heated by any ordinary means, the green and grey parts change to a ruby or ruby-amethystine colour, and that whether surrounded by air, or vapour of alcohol or ether. Even after heating, they adhere only as a dust to the plates, except when the temperature applied to those on glass has been very high. Agate pressure confers the green character on the heated deposits, and also, in frequent cases, upon that which has not been heated. All things considered, there can be no reason to doubt that the deposits thus made to vary in the colour of the transmitted light, consist of pure metallic gold.

Thin films of Gold.—If a very weak solution of chloride of gold, free from excess of acid, and containing about $1\frac{1}{2}$ grain of metal to 2 or 3 pints of water, be placed in a very clean glass or glazed vessel, in a quiet place, and then two or three small particles of phosphorus be laid floating on the surface, and the whole covered over and left for twelve or more hours, the gold will be reduced, covering the whole of the surface with a film, thicker near the phosphorus than at other parts. This film may be raised from the fluid by plates of glass, and washed and dried on the plates, and is then ready for examination. The thinner parts of such a film are scarcely visible, either by reflected or transmitted light; the transition to thicker parts is gradual, the thickest being opaque, and their reflexion that of dense gold. The colour by transmitted light varies, being grey, green, or dull violet. The films are porous, and act as pure gold, resisting all the agents which metallic gold resists. When heated, the transmitted colour changes towards amethyst and ruby; and then the effect of pressure in producing a green colour is in many cases very remarkable,—even a touch with a card or the finger being able to cause the change.

Gold fluids.—Whilst the particles of phosphorus are producing a film on the surface, it frequently happens that streams of a red colour descend from them through the fluid; and if the phosphorus be submerged, and left for twenty-four or forty-eight hours, this red product is easily and abundantly obtained. If the gold solution be placed in a very clean bottle, and then a few drops of a solution of phosphorus in ether be added, and the whole agitated from time to time, the ruby fluid is obtained in a shorter period. This fluid is apt to change in colour, becoming amethystine, violet, purple, and finally blue; impurities of certain kinds in very small quantities cause this change. It is hardly possible to clean a vessel so well that the first portion put into it does not alter. Most saline bodies produce the change; a trace of common salt readily makes it manifest. That all these fluids are coloured by diffused particles is shown by the circumstance, that on being left for a shorter or longer time, the particles sink, forming a coloured stratum of deposit; many months, however, are required for even the partial separation of the finer ruby particles. When a light is looked at through the fluid, the latter appears transparent; but when the eye is on the illuminated side, then the fluid is seen opalescent. If a cone of sun-rays be thrown by a lens into the fluid, the illumination of the particles within the cone shows their presence as undissolved bodies. It is believed that all the particles being metallic gold, the ruby are in the finest state of division, the blue in a more aggregated condition. Though the ruby particles, whilst freely diffused, are easily changed in colour, and as it is supposed by aggregation, still they may in some degree be separated by a filter; for on passing the fluid several times through a paper filter, the latter associates much of the rubifying substance with itself, and becomes of a rose colour; it may then be well washed and dried, and contains the ruby particles located, as it is believed, and prevented by their attachment to the paper-fibres from undergoing mutual aggregation. In this state their character is not altered from ruby to blue by salt or acids; they resist those chemical agents which are resisted by gold, but are dissolved by chlorine, cyanides and the other substances capable of acting on gold. Heated either in oxygen, hydrogen, or air, no change of tint or quality is induced at such temperatures as the paper can bear; or, as far as can be judged, at any higher temperature.

A ruby glass, coloured by gold, is well known. This is considered by the author as analogous to the ruby fluid just spoken of, being a diffusion of gold particles through vitreous matter. The ruby fluid by association with jelly is rendered much more permanent than before; and then it may by a little warmth be had in the fluid state, or by cooling as a tremulous jelly, or by desiccation as a hard ruby solid, presenting all the transitions between the gold fluid and the ruby glass. By soaking the dried jelly and then warming it with water, these transitions may be passed through in the reverse direction, and so on, any number of times.

The relations of gold (and other metals) to polarized light are of the following nature. A leaf of gold inclined at a certain angle across a ray of polarized light (the inclination not being in the plane of polarization or at right angles to it), affects it as a thin plate of any uncrystallized transparent substance would do, *i. e.* the light appears in the analyser, and the plane of polarization is rotated; or if a leaf of gold be held in an inclined position across a ray of unpolarized light, the beam is polarized as it would have been in passing through a like inclined plate of uncrystallized transparent matter. The gold greened by heating or pressure, when thus examined, does not appear to have acquired any particular tension or structure. Sulphide of carbon and crown-glass are optically so near each other, that a plate of the latter immersed in the former is neutralized; and though placed in an inclined position to a ray of light, either polarized or not, does not then affect it; but gold (and all metals) is still far above either of these. Hence the gold films obtained by phosphorus, when attached to glass, could be examined, and were found to have the optical properties of leaf-gold; the effect having no reference to the *thickness* of the film, but being most perfect in the thinner films because they were in a more regular and perfect condition. It should be remembered that these films are not continuous layers like coats of varnish or fluid, but easily pervious to vapours. In like manner the deposits of gold (and other metals) obtained by electric deflagrations, were examined and found to have the same marked qualities in a high degree; places where the film was scarcely visible on the glass, instantly showing the presence of the gold by their action on the polarized ray. In the same manner the very thin and almost invisible films, deposited occasionally on the sides of the vessels con-

taining the gold fluids, showed themselves as gold. The thinnest layer of the fluid itself, however rich in particles, held between two plates of glass, acted no otherwise than a layer of water. It appears by the deflagrations that the particles of gold must be deposited in a plane, and then, though discontinuous, they act in the manner of continuous films of ordinary uncrystallized transparent bodies.

As to the quantity of gold in the different films or solutions, it can at present only be said that it is very small. Suppose that a leaf of gold, which weighs about 0·2 of a grain, and will cover a base of nearly 10 square inches, were diffused through a column having that base, and 2·7 inches in height, it would give a ruby fluid equal in depth of tint to a good red rose; the volume of the gold present being about the $\frac{1}{500,000}$th part of the volume of the fluid; another result gave 0·01 of a grain of gold in a cubic inch of fluid. These fine diffused particles have not as yet been distinguished by any microscopic power applied to them.